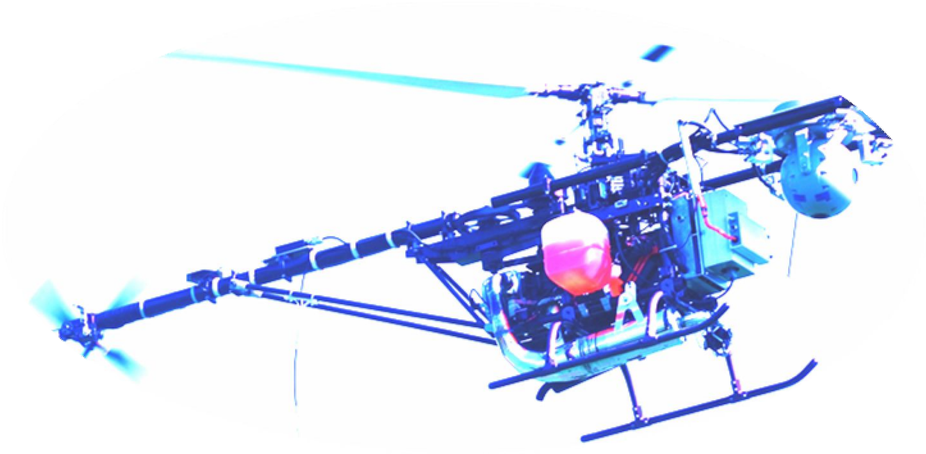
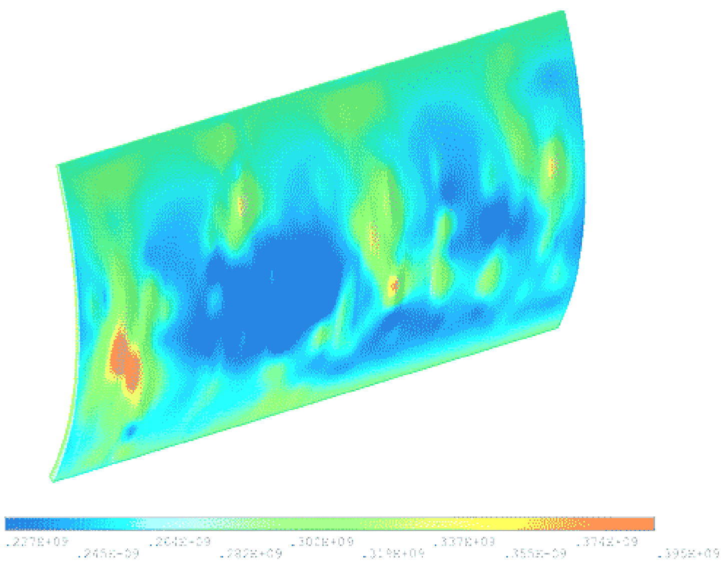
AMT-ASMOS
aeromobile system for monitoring of pipelines





Pipelines are specific examples of pipework and piping systems used to convey fluids over significant distances. This document is concerned with the monitoring of pipelines – an arrangement of pipes and pipe fittings (e.g. elbows, bends, tees, reducers, flanges) including equally the above ground pipelines, the buried pipelines and submarine pipelines (buried or not).

Each operator establishes its own requirements for the medium and long-term inspection of the pipeline in order to identify, prioritize, assess, evaluate, repair and validate the integrity of hazardous liquid pipelines that could, in the event of a leak or failure, affect High Consequence Areas like population areas; areas containing drinking water and ecological resources that are unusually sensitive to environmental damage; and commercially navigable waterways.

AMT-ASMOS aeromobile system may equally be used to monitor the pipeline system for transportation of crude oil, processed oil products, natural gas, chemical liquids, water and other substances to ensure continuing 'fitness for intended purpose'.

AMT-ASMOS combines hardware and software for performance of non-destructive testing works and indirect inspection & technical diagnostics of underground (buried) and underwater (buried or not) pipelines without stopping the pipeline, without excavation the soil or other interference in the normal mode of operation of the object.
The system includes but not limited to the RPAS (remotely piloted aerial system), cameras, thermo vision, means of telemetry, and SR-20/60 and M-02 non-destructive testing device, created on the basis of thin-film magnetoresistive transducers, determining high sensitivity of the device and the selectivity of diagnostics.

The principle of operation of the system in accordance with the international classification refers to the methods of the Indirect examination. It corresponds to the requirements of the USA Federal regulation (Title 49: Transportation, Part 195 –Transportation of Hazardous liquids by pipeline, Subpart H—Corrosion Control).

Indirect examination procedures include criteria for identifying and documenting those indications that must be considered for excavation and direct examination, including at least the following:

Defined defects:

• Stress-deformed state segments;
• Stratification of metal;
• Defects in welds;
• Corrosion-fatigue strength segments;
• Local damages (surface defects, cracks, or areas where metal is flaking off, corrosion);
• Changing the geometry of the pipeline segments (plunge, bending, bloating, rise), unintended movement or abnormal loading of a pipeline by environmental causes, such as an earthquake, landslide, or flood, that impairs its serviceability.

The most commonly experienced failures, or threatened failures, are associated with either internal or external corrosion of the pipe wall. Other failures may involve other metal loss mechanisms, such as erosion, fretting/chafing or gouging.

Fig.1 Violation of the geometry of the segment of buried pipe that caused the stress strain state at a critical level.

Fig.2 Plot of pitting corrosion, detected by indirect examination method in the segment of buried pipeline.

Fig. 3 Plots of pitting corrosion, the detected by indirect examination method in the buried pipeline. The depth of the buried pipe trench is 4 m.

Advantages of the M-02

• Does not require preparation of a pipeline, stopping or changing the operating mode;
• High validity of defects identification (efficiency up to 93 %);
• High performance time (up to 200 km per day);
• Allows to inspect areas inaccessible for in-line inspections by so called "pigs"- small computers that travel through the pipe collecting, storing and transmitting information that is analyzed by inspectors;
• Automatic tracing with the subsequent application of the route the topographic map of the area;
• Processing of the primary information for indicating the location of magnetic anomalies in the «on-line» mode.

The main characteristics of complex M-02:

The diameters of the surveyed pipeline
of 159 mm to 5 m

Accuracy of definition of coordinates
+_ *0,5 m*

The precision depth of detected defects
starting with 20 % of the thickness lack of the pipe wall

The memory capacity for continuous recording of information
on 500 km of the route with step scanning 0.5 m

Range of working temperatures
from minus 35 degrees C to + 45 degrees C

Features of the technology

Zone	Metal loss	Instrumental error	Accuracy of definition of coordinates	Detection of defects, %
Green	0-30%	+_ 25%	+_0,5 m	90-95%
Yellow	31-50%	+_ 15%	+_0,5 m	90-95%
Red	> 50%	+_ 10%	+_0,5 m	90-95%

* Assessment of the technical condition of the pipeline (**green**- good; **yellow**- satisfactory, **red**- unacceptable). The specified division is of probation and can be modified as agreed with the customer as per specific Safety Regulations ("Safety-Related Condition Report").

At the first stage of works an aerial photography of the territory in the pipelines location is carried out for the construction of three-dimensional terrain models of high resolution in a variety of formats.

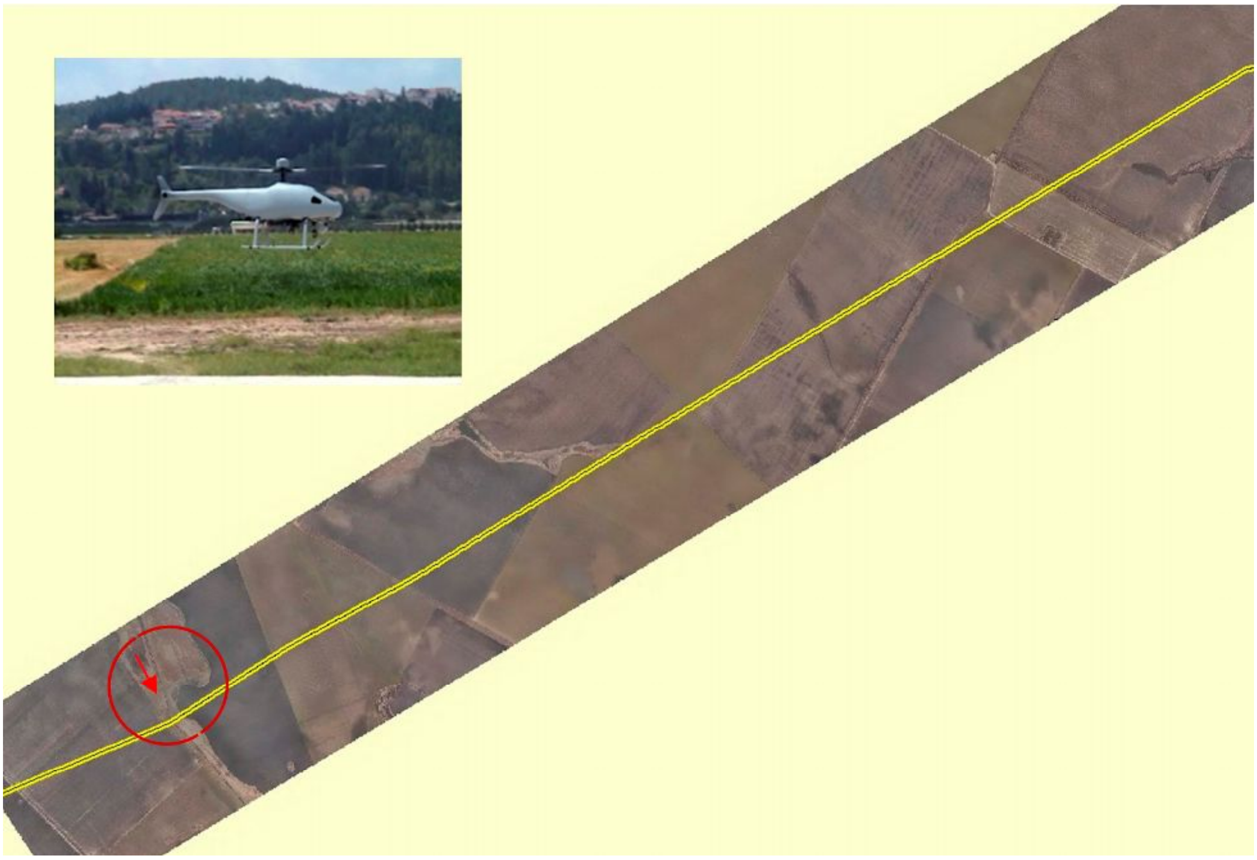


Fig. 4 Profile of the area of trunk pipeline

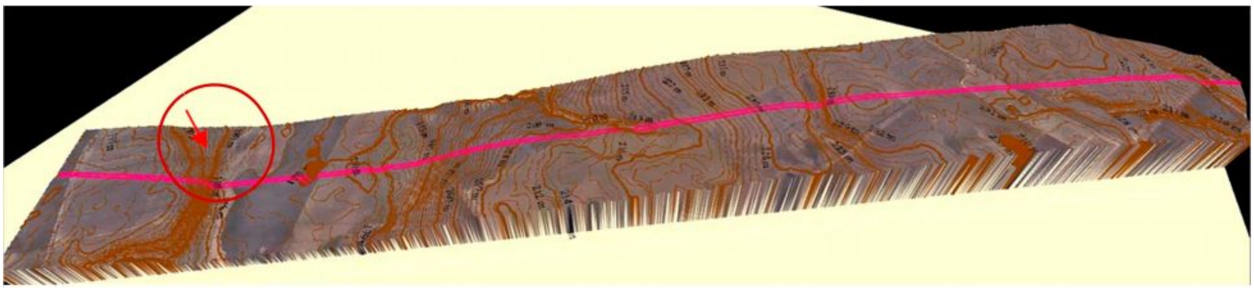


Fig.5 Profile of the area of trunk pipeline

Fig. 6 3D model of pipeline

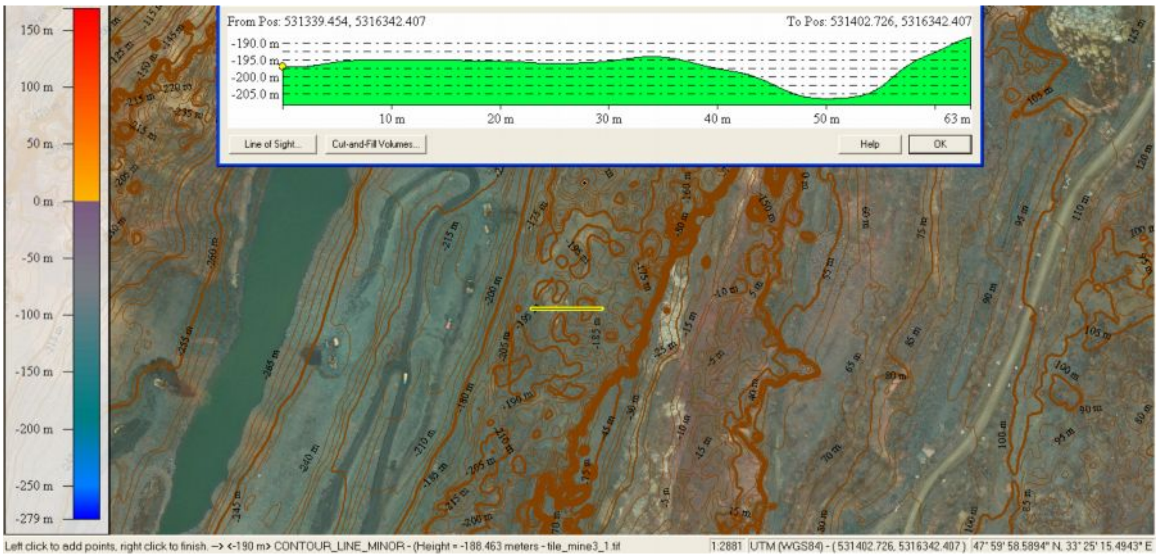


Fig.7 Fragments of geo-information files for 3D modeling of pipe-line.

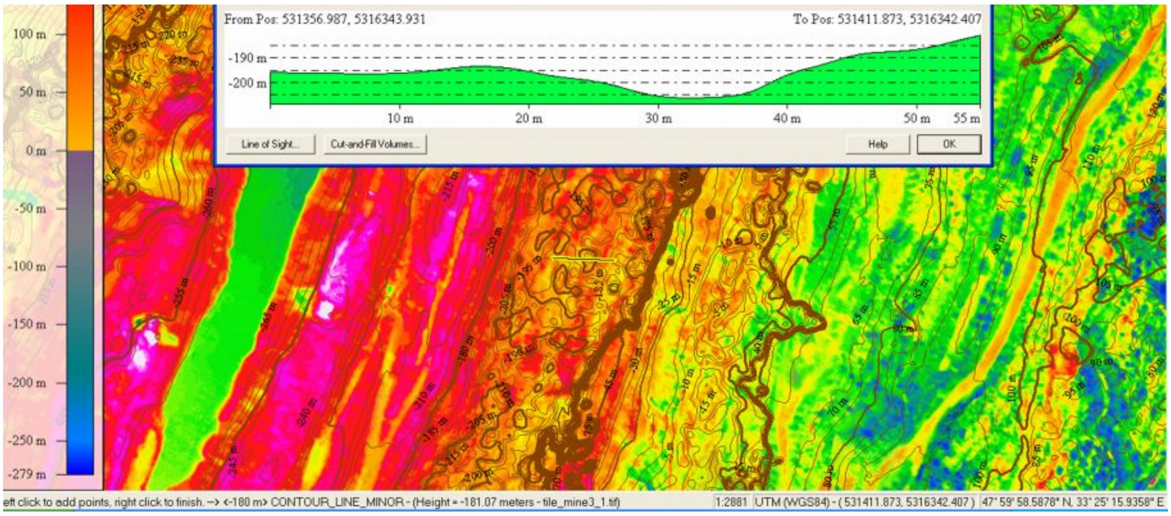
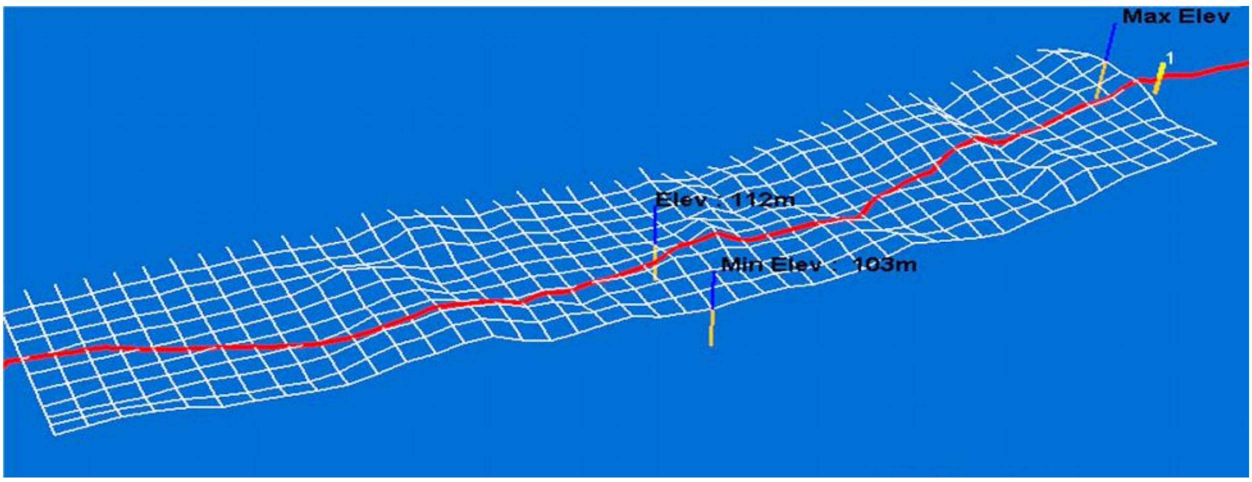


Fig.8 Digital elevation model of the area surface (thermal map).

Start Position: 531356.987, 5316343.931,
Start Height: -195.787 m
End Position: 531411.873, 5316342.407,
End Height: -180.731 m
Straight-Line Distance: **54.929** m,
3D Distance on Surface: **74.188** m
Vertical Difference (Start to Finish): 15.1 m
Minimum Elevation on Path: -206.344 m
Maximum Elevation on Path: -180.731 m
Azimuth: 91° 54' 12.7", Slope/Tilt: 15.33°

Fig.9 Digital elevation model sample description.



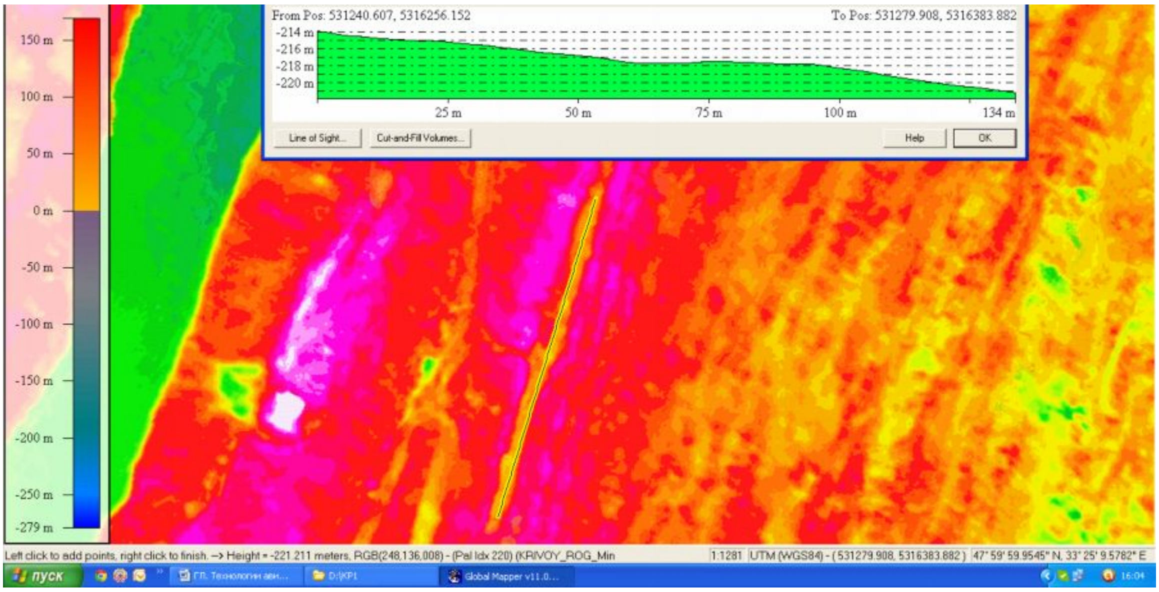


Fig. 10 Digital elevation model (thermal map) sample.

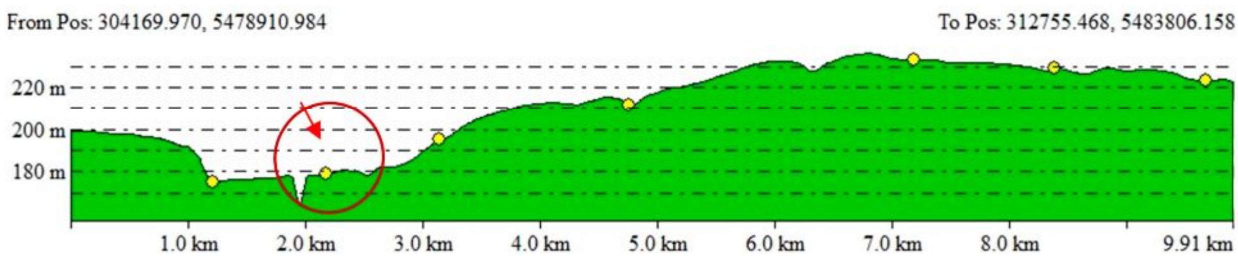


Fig. 11 Vertical elevation model sample.

The analysis of tables and three-dimensional maps allows the Operator to detect those segments of the pipeline, which with high probability may require greater attention in the course of subsequent inspections. These tables also could help in planning 60-day, 180-day Condition inspections within segments identified as those that could potentially impact the pipeline integrity.

The First stage inspection results report includes:

• High accuracy data on the position of the pipeline in the plan and in height, with a real relief of the locality;

• Identification of segments of the pipeline with significant deviations from the design documentation;

• The combination of induction, visible and infrared survey data in a convenient for the pipeline Operator digital three-dimensional model.

The second stage of works as per AMT-ASMOS technology includes the installation of autonomous sensors buried in the ground at a certain depth. The intelligent sensors will collect and store the information on a condition of work of the pipeline.

Fig. 12 Intelligent sensors.

The Sensors constantly monitor and analyze the characteristics of the noise of the pipeline system and according to the given algorithm can detect and identify the location of the possible anomalies in its work (the occurrence of leaks, taps, etc.).

The Sensors collect information on the distribution and character of the noise around the clock and keep it in your memory in the form of basic graphics. The emergence of a constant background noise of the relevant noise leakage, or other distinctive signals, generates a signal about the deviation of the work schedule of the pipeline system from the basic algorithm.
The information obtained by the sensor, the measured levels and the nature of the noise performance of the pipeline system is stored 10 days, and information on the assessment of the level of deviation of up to 180 days.

The sensors are equipped with data transfer telemetry system. The information is encoded.
The AMT-ASMOS includes RPAS (remotely piloted aerial system) or UAV which can receive automated reports of «registered events» from all the Sensors during the flight over along the pipeline from the height of 200 m. Each Sensor has individual number, specified GPS location, each message is registered and stored individually, which gives timely signal about all possible defects in pipeline operation (possible leakage, unauthorized interference, even terrorist activity).
In the future the data can be used for a full analysis of the events in the operation period of the pipeline system, in order to improve it.
All the Sensors could be programmed in accordance with AMT-ASMOS for the emergency alarm transmission to the RPAS “red level” (leakage), “orange level” (probable leakage).

When performing scheduled flight along the pipeline RPAS receives “red level” alarm, the operator of RPAS can send a command to UAV helicopter to land at the detected area for using a contact type of diagnostics device of «H X» type.

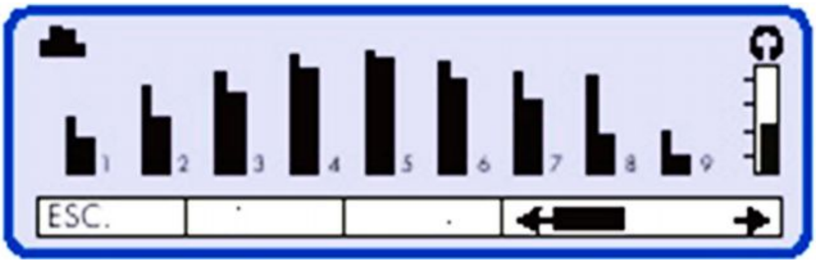


Fig. 13 «H X» diagnostic device scale.

«H X» devise can detect and estimate the acoustic signals from buried pipeline and transfer the processed data to RPAS operator. After the calculation and processing of the received echo, noise levels are displayed in the form of narrow graphic bands. A narrow segment of the stripes indicates the level of environmental noise, a wide segment - the noise of the leak. In the place of the pipeline, where a wide segment has a maximum level - is the place of leakage. This information is displayed on the navigation tactical display system, with the execution of the mark in the Protocol route of the flight. Having received such «confirmation» of alarm signal from the RPAS the AMT-ASMOS operator specify the location of the place of leakage, and evaluating the degree of hazard. After that the RPAS operator immediately informs the pipeline operator about any “red level” or “orange level” situations.

AMT- ACMOC aeromobile system for monitoring of pipelines operates 24 hours a day al at weather conditions. The Sensors collect data and transmit it to RPAS as soon as weather conditions allow the flight. Any RPAS cam control as much as 200 km of pipeline per day depending on the complexity of the terrain and the number of required parameters.
A groups of RPASs can cover significant areas simultaneously with multiple pipeline systems.

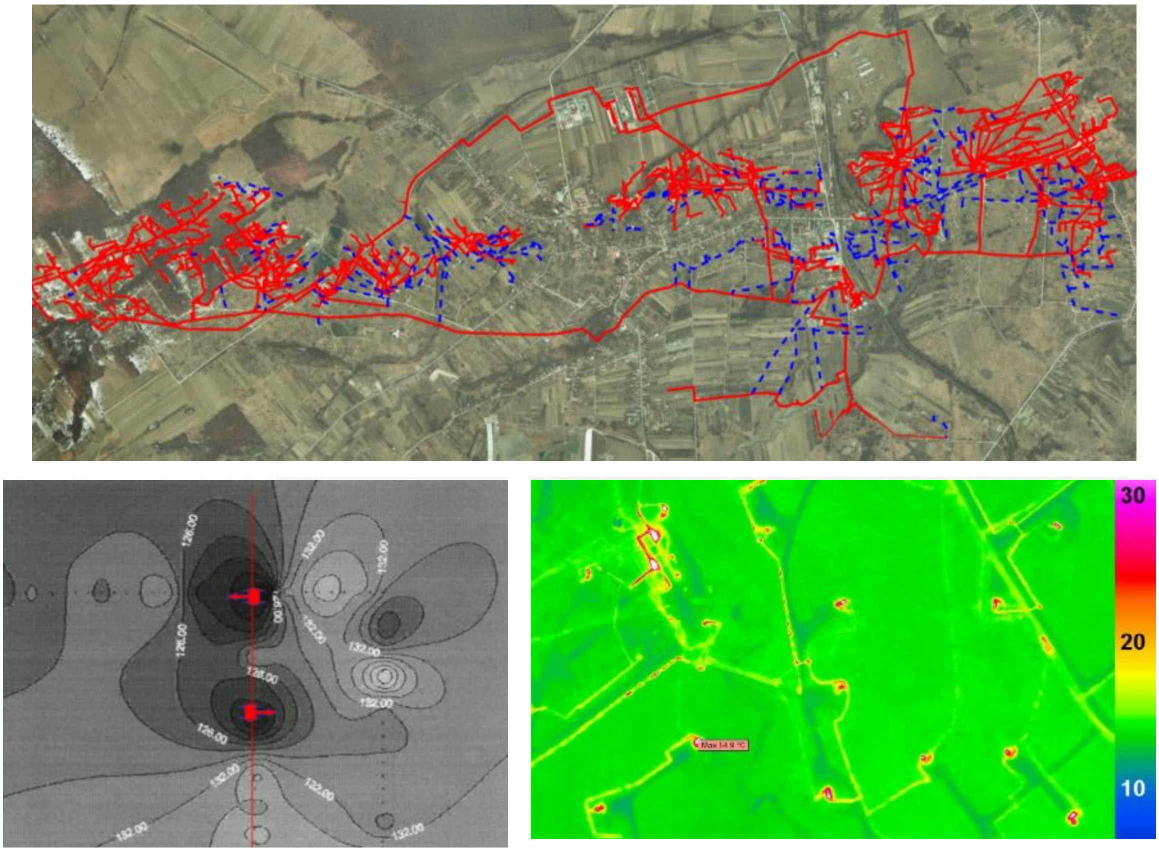


Fig. 14 Diagnostic of multiple pipeline systems.

The system can also be applied to the control of pipelines located at the bottom of the bays, rivers, and how in-depth the bottom, so free and lying on the bottom. If the water depth exceeds a few meters, and the signal reflected from the pipeline is subject to interference, the UAV has a waterproof capsule sensor, which slowly towing on the cable in the water.

asmos08@mail.ru